Appendix S1

For each size-season combination, four variance structures were fit to the global model using generalized least squares regression in *nlme*. The global models for spring and summer were:

Rate spring ~ pos + tpi + prr + Avg.Max + soak.rain.
Rate summer ~ pos + stream.dist + prr + Avg.Max + time.rain + ndvi.

pos = position (under or on top of leaves); tpi = topographic position index; prr = potential relative radiation; Avg.Max = maximum temperature averaged for previous 7 years; soak.rain = time since last rain event ≥5mm, averaged for previous seven years; ndvi = normalized difference vegetation index.

The four variance structures fit to the global model and assessed by AIC were:

1) Variance differing by model position:
   varIdent(form=~1|pos)
2) Variance differing as an exponential tpi*, varying by model position:
   varExp(form=~tpi|pos)
3) Variance differing as an exponential temperature, varying by model position:
   varExp(form=~Avg.Max|pos)
4) Combination of variance functions, including variance differing by position and variance differing as an exponential temperature, varying by model position:
   varComb(varIdent(form=~1|pos), varExp(form=~Avg.Max|pos)

*Note that TPI was replaced by distance from stream in the summer models

Using the variance structure with the lowest AIC, we fit random effects using restricted maximum likelihood (REML), and again assessed model fit using AIC. The random effects parameterizations tested were:

random=~1 + position | date
random=~1 + position | date/transect
random=~1 + position | date/ transect /locale
random=~1 + position | locale
random=~1 + position | date/locale
random=~1 | date

When *position* precedes the "bar", it indicates random slopes that vary by position. Terms following the "bar" are random intercepts, with "forward slashes" indicating nestedness (e.g., date/transect = transect within date).

Appendix S2

Abundance Model

Data used for generating the spatial abundance model (Peterman & Semlitsch, 2013), adult and juvenile multistate models, and for estimation of salamander length were collected 8 April to 28 May 2011 at Daniel Boone Conservation Area. Over this time period, 135 plots (3 m x 3 m) spaced at least 75 m apart were surveyed seven times. Surveys consisted of carefully lifting all moveable rocks, logs, and bark within a plot. All salamanders were captured by hand, weighed using a portable digital balance, measured using digital calipers, sexed, and then returned to the point of capture.

We used a Bayesian binomial mixture model to estimate abundance at each of the 135 survey plots, based on the count data from each of the seven survey periods (Peterman and Semlitsch 2013).

$$logit\ (Detection\ (p)) \sim \alpha_0 + \alpha_1 Date + \alpha_2 Bark + \alpha_3 Soak.Rain + \alpha_4 Soak.Rain^2 + \alpha_5 Temp + \alpha_6 Temp^2 + error$$

$$log\ (Abundance\ (\lambda)) \sim \beta_0 + \beta_1 NDVI + \beta_2 TPI + \beta_3 TWI + \beta_4 PRR + \beta_5 TWI*PRR$$

Date is the Julian date of the survey, Bark is the total surface area of bark available to search at a plot, Soak.Rain is the number of days since ≥5 mm of rainfall, Temp is temperature in degrees Celsius, NDVI is the normalized difference vegetation index (i.e. canopy cover), TPI is topographic position index, TWI is topographic wetness index, and PRR is potential relative radiation. The error term in this model is a site-survey random effects over-dispersion term (Kéry & Schaub, 2012). Details about each of the covariates used in these models can be found in Peterman & Semlitsch (2013)

Abundance estimates from this model were used in the spatial correlation analysis (Fig. 2c in text). For this study, we also re-ran this model replacing the individual environmental covariates in the abundance model with the estimated surface activity time (SAT) at each survey plot. SAT was measured using the model derived from adult-summer plaster replicas: As described in the main text, since temperature and rain are temporal covariates, we modeled them using the mean from seven years of data.

$$SAT = -1.794 + 1.155*Pos + 0.004*TPI + 0.000034*PRR + 0.059*Temp + 0.205*Soak.Rain$$

Where Pos is the position of the plaster replica (under or on top of the leaves), TPI is topographic position index, PRR is the potential relative radiation, Temp is the maximum air temperature (°C) during the day preceding model deployment, and Soak.Rain is the number of days since a rainfall ≥5mm.

As such, the models used in our re-analysis of the count data for this study were:

$$logit\ (Detection\ (p)) \sim \alpha_0 + \alpha_1 Date + \alpha_2 Bark + \alpha_3 Soak.Rain + \alpha_4 Soak.Rain^2 + \alpha_5 Temp + \alpha_6 Temp^2 + error$$

$$log\ (Abundance\ (\lambda)) \sim \beta_0 + \beta_1 SAT$$

Posterior summaries were based on 500,000 Markov chain Monte Carlo iterations thinned at a rate of 250 following a burn-in of 250,000 iterations. From each model we calculated the mean and 95% credible interval (CRI) for each parameter. Model convergence was assessed using the Gelman-Rubin statistic (Rhat) (Gelman, Meng & Stern, 1996). Posterior predictive assessment of model fit was done using Bayesian p-value as well as a Chi-square discrepancy measure (Gelman *et al.*, 2004, Kéry, 2010).

Results of abundance model

The model fit the data well (Bayesian p-value = 0.516; Chi-square discrepancy = 0.996), and convergence was clearly reached for all model parameters (Rhat = 1.00). Surface activity time, as estimated from the adult summer replicas, was a significant predictor of abundance in this model, with a mean parameter estimate of 0.219 (0.087–0.347 95% CRI) on the log scale.

Parameter	Mean	St. Dev
Intercept	0.5729	0.09351
SAT	0.2191	0.06671

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Multistate Models

Using detection/non-detection data from the seven samples of 135 plots, multistate models were parameterized by Peterman and Semlitsch (2013) as follows, and analyzed using program PRESENCE v.3,1 (MacKenzie *et al.*, 2009):

$$logit\ (Detection\ (p)) \sim \alpha_0 + \alpha_1 Date + \alpha_2 Bark + \alpha_3 Soak.Rain + \alpha_4 Soak.Rain^2 + \alpha_5 Temp + \alpha_6 Temp^2$$

$$logit\ (Occupancy\ (\psi)) \sim \beta_0 + \beta_1 NDVI + \beta_2 TPI + \beta_3 TWI + \beta_4 PRR + \beta_5 TWI*PRR$$

$$logit\ (Conditional\ Occupancy(R)) \sim \beta_0 + \beta_1 NDVI + \beta_2 TPI + \beta_3 TWI + \beta_4 PRR + \beta_5 TWI*PRR.$$

Date is the Julian date of the survey, Bark is the total surface area of bark available to search at a plot, Soak.Rain is the number of days since ≥5 mm of rainfall, Temp is temperature in degrees Celsius, NDVI is the normalized difference vegetation index (i.e. canopy cover), TPI is topographic position index, TWI is topographic wetness index, and PRR is potential relative radiation. Conditional occupancy can be defined as the probability of the focal size class (gravid female salamanders or juvenile salamanders) occurring at a plot, given that the plot is suitable to be occupied. Details about each of the covariates used in these models can be found in Peterman & Semlitsch (2013).

In this study, the occupancy data were re-analyzed using adults and juveniles (rather than only gravid females and juveniles) as the focal size classes. Further, occupancy and conditional occupancy model parameters were replaced by the estimated surface activity time (SAT):

$$logit\ (Detection\ (p)) \sim \alpha_0 + \alpha_1 Date + \alpha_2 Bark + \alpha_3 Soak.Rain + \alpha_4 Soak.Rain^2 + \alpha_5 Temp + \alpha_6 Temp^2$$

$$logit\ (Occupancy\ (\psi)) \sim \beta_0 + \beta_1 SAT$$

$$logit\ (Conditional\ Occupancy(R)) \sim \beta_0 + \beta_1 SAT.$$

Results of multistate models

SAT was a significant predictor of the conditional occupancy probability of juvenile salamanders, but not of adult salamanders.

Juvenile salamanders, conditional occupancy probability (R)

Parameter	**Mean**	**St. Error**
Intercept	0.506	0.183
R	0.753	0.350

Adult salamanders, conditional occupancy probability (R)

Parameter	**Mean**	**St. Error**
Intercept	2.477	0.580
R	0.114	0.209

* Parameter estimates in the multistate tables above are on the logit scale.

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Table S1. Table of Pearson's *r* correlation coefficients for surface activity times estimated from adult- and juvenile-sized models in spring and summer. All correlations are significant at $P<0.0001$

Model	**Juvenile spring**	**Adult spring**	**Juvenile summer**	**Adult summer**
Juvenile spring	-			
Adult spring	0.95	-		
Juvenile summer	0.77	0.85	-	
Adult summer	0.56	0.62	0.69	-

Figure S1. Maps of surface activity times, measured in hours, estimated for adult- and juvenile-sized models in spring and summer. Note that the range and scale of activity differs for each map.